

STATE ENGINEERING EXPERIMENT STATION

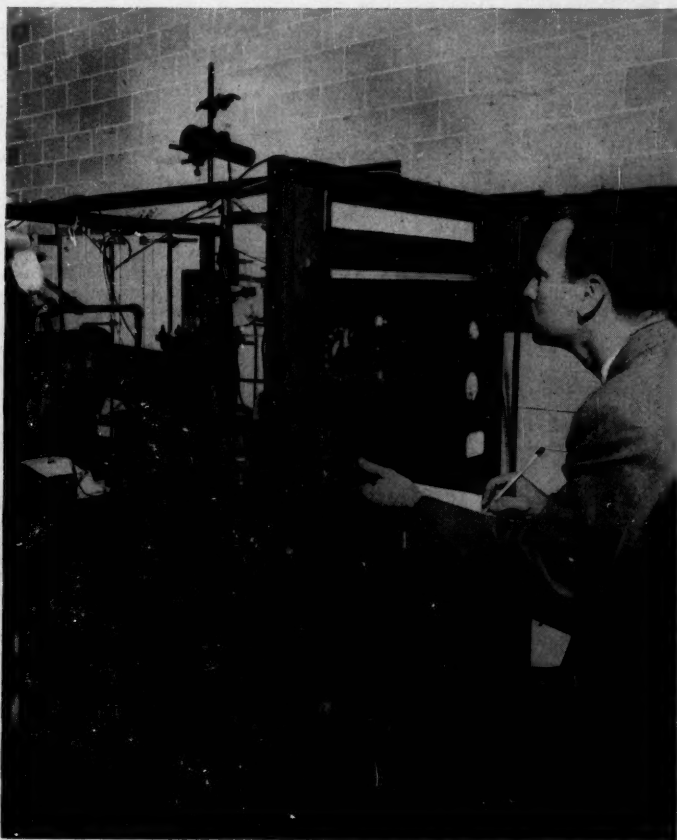
The Research Engineer

GEORGIA SCHOOL OF TECHNOLOGY

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The Research Engineer

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FUNDAMENTAL RESEARCH

Before the advent of the new synthetic rubber industry, there were many years of patient, intelligent research on polymerization, monomer synthesis, compounding, and physical studies. Before the devastating explosions at Hiroshima and Nagasaki, there were decades of accumulated work on atomic structure, nuclear composition, radioactivity, and the behavior of ultimate particles of matter.

Much of this research was performed because scientists, somewhat like small boys, are ever imbued with the desire to know "why" a thing is so, regardless of whether the answer means dollars in the bank on the following day. That much of this "fundamental" research has later found practical application is testimony to its ultimate value, but even those studies which have led to no direct use have served to advance the boundaries of knowledge and to stimulate further investigations.

Colleges have long been the leaders in fundamental research, as could be expected; the search for knowledge is a basic part of education. In recent years, however, industry has come to realize the value of this sometimes intangible work and has often served as sponsor

for it, as have government agencies and technical societies.

The ultimate aim of research is the same, be it fundamental or applied: to learn the solution to unanswered questions. Early scientists were forced to make their attempts with crude and simple tools, but their findings have led to fields of science of such increasing complexity that it is often no longer possible to gain further information by the test tube route.

Thus it is that every research organization is always intent on adding to its supply of modern scientific tools, and thus it is that Georgia Tech is proud to announce the completion and initial use of its mass spectrometer. We recommend to you the article by its builder, for we believe that this article and that on low temperature research are indicative of the growing strength of Georgia Tech's efforts in fundamental research, efforts which must be continued and enlarged if science and technology are to be advanced in this region.

In this connection, we are glad to note the recent formation at Georgia Tech of a club of the Society of Sigma Xi. Fundamental research is the primary interest of such clubs, and the one at Georgia Tech will serve a worthy purpose.

THE GEORGIA TECH MASS SPECTROMETER

By DWIGHT A. HUTCHISON

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In this age of increasing scientific complexity, it is often no longer possible to obtain certain information needed in research and industry by use of the relatively simple instruments of the past. Thus it is, for example, that the electron microscope has extended the horizons of the optical instrument, making possible knowledge which has previously been unobtainable. Man has never been content, however, to consider only those objects of macrodimensions, and he has long been engaged in scientific exploration of atomic and molecular structures and their significance. In such research, an instrument known as the mass spectrometer has recently been playing an important role.

The Georgia School of Technology is at present engaged in augmenting its supply of those scientific instruments which are required for modern research, both fundamental and applied. In connection with certain projects which will be mentioned later, the use of a mass spectrometer became necessary, and it was decided to construct such an instrument to meet these and future requirements. This mass spectrometer is now in operation and has already aided in the solution of important problems.

DEVELOPMENT OF THE INSTRUMENT

The mass spectrometer is an instrument by which the relative abundance of charged, gaseous molecules or atoms of different mass may be determined. The component parts of the instrument consist of the mass spectrometer tube, a gas handling system, a small magnet to control the path of a beam of bombarding electrons, a large magnet to sort the various ions according to their mass-to-charge or m/e ratio, an ion current amplifier, the associated power supplies, and two pumping systems for the evacuation of the mass spectrometer tube and the gas sample assembly.

Gas samples to be analyzed are introduced at a controlled rate into the ion source region of the mass spectrometer tube at a pressure of approximately 10^{-4} mm mercury pressure. The molecules of the gas are there bombarded by a beam of electrons of

controlled energy, obtained from a thermionic filament and accelerating plates. These electrons, on collision with the gas molecules, produce gaseous ions.

Pure gases or vapors yield many different kinds of ion fragments which correspond to different modes of breakdown of the parent molecule by electron bombardment or to the different isotopic species present. The ions thus formed are given a controlled amount of energy by means of a stabilized high voltage supply and an assembly of nichrome accelerating plates, and these ions are then directed down the mass spectrometer tube by a system of slits in the accelerating plates and are caused to enter a magnetic field perpendicular to the lines of force. It is at this point, between the pole faces of the large electromagnet, that ion separation begins. The magnetic field causes ions of different mass-to-charge ratio to follow individual curved paths, the difference in these thus permitting separation of the various ions for analysis. By adjustment of the ion accelerating potential or the magnetic field, or both, the various mass ion beams can be focused on a collector cup at the end of the mass spectrometer tube, and their intensity may be measured, thus affording a means of measuring the relative abundance of different mass ions.

The mass spectrometer in its present state, as is the case with all great scientific instruments, has been the result of a series of developments, extending back to about the year 1909 when J. J. Thomson published a number of papers on his positive ray or parabola spectrometers. In 1919, F. W. Aston introduced a new type of positive ray apparatus, designed primarily for mass measurements, which he named the mass spectrograph. With this instrument and later improved instruments, Aston was able to show the existence of isotopes in most of the elements; to obtain fairly precise measurements of their mass and abundance, and thus to construct a mass spectrographic system of atomic weights which was in good agreement with chemical atomic weights. The Aston type instrument and numerous others which are designed primarily for

mass measurements have proved extremely important because of the Einstein relation that mass is equivalent to energy. In transmutation studies, for example, a knowledge of precise masses of atomic nuclei allows one to predict which reactions are permitted from energy considerations and the amount of energy that should be released in a particular reaction. Precise measurement of isotopic masses is one of the few methods of obtaining information which is essential to the understanding of the nuclei of atoms.

In 1933, N. F. Barber¹ showed that if a beam of ions enters and leaves a uniform magnetic field normal to the pole edges, the ions are brought to focus on a line extended from the source through the center of curvature of the ion beam. This general property made possible the application of sector shaped fields to many different types of investigations. W. E. Stephens², in 1934, was able to give experimental proof to the theory by using a 90° sector refocusing field as an electron lens.

An application of the sector field to mass spectrometry was reported in 1940 by A. O. C. Nier³ who was able to obtain good resolution with an inexpensive magnet. Further, the construction of his mass spectrometer tube was greatly simplified by using metal-to-glass seals which allowed the ion beam to be enclosed in a copper tube from the ion source to the ion collector, thus eliminating the troublesome effects of electrostatic charges on the ion beam.

Nier's type of instrument has proved satisfactory for measuring differences in the relative abundance of isotopes from different sources, but, because of certain discriminatory effects, is unsatisfactory for determining absolute abundance ratios. This property of the Nier type instrument, however, does not place serious restrictions on the type of experimental investigations open to the physical chemist. The instrument is adequate for use in the study of isotopic tracer problems and isotopic separation processes.

The terms "mass spectrograph" and "mass spectrometer" have so far been used

¹N. F. Barber, *Proc. Leeds Phil. Soc.* 2, 427 (1933).

²W. E. Stephens, *Phys. Rev.* 45, 513 (1934).

³A. O. C. Nier, *Rev. Sci. Inst.* 11, 212 (1940).

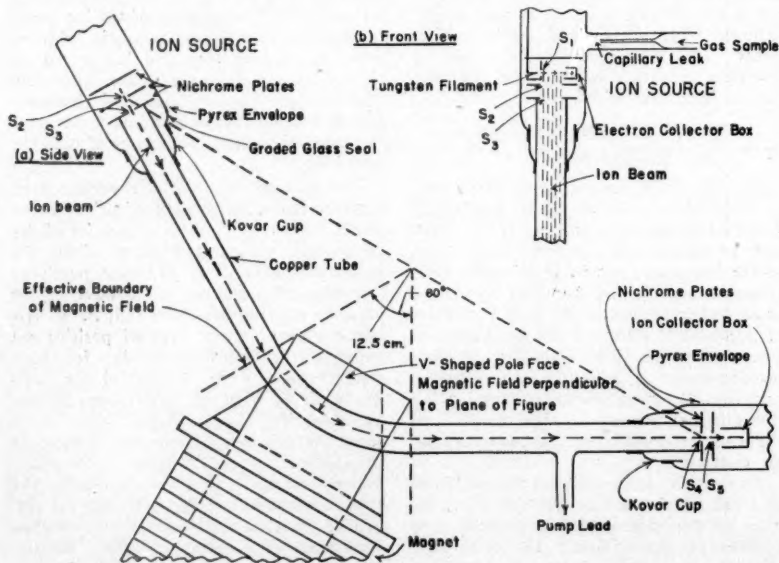


Figure 1. Schematic diagram of the mass spectrometer tube and electromagnet.

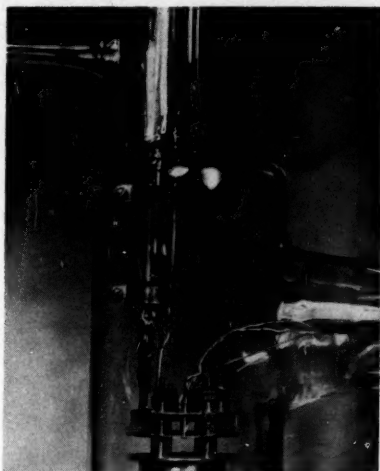


Figure 2. View of plate arrangement and thermionic filament leads in the ion source (see Figure 1b).

without definition. "Mass spectrograph" is generally used to refer to instruments which employ a photographic recording of the different mass ion beams and are intended primarily for mass measurements. The term "mass spectrometer" is reserved for those instruments which employ the electrical recording of different ion beams and are intended chiefly for the measurement of the relative abundance of isotopes.

THE GEORGIA TECH INSTRUMENT

Inasmuch as this writer's research work has been concerned with the electrolytic separation of isotopes⁴ and the application of isotopes in tracer studies⁵, it was decided to construct a mass spectrometer patterned after the type constructed by Nier³. A general view of the Georgia Tech instrument is shown on the cover of this issue.

Figure 1 presents. (a) a schematic diagram of the mass spectrometer tube employed in the Georgia Tech mass spectrometer and also a diagram (b) of the ion source

region at right angles to the view presented in (a). The ion source region is also pictured in Figure 2, while Figure 3 shows a view of the electromagnet.

The gas sample to be analyzed is introduced into the region above S_1 of the mass spectrometer tube by means of a capillary leak. It passes through the ion source region and down the tube, where it is pumped out of the pumping lead. Before a gas sample is introduced, the pressure in the tube is maintained at approximately 10^{-6} mm mercury or better; after the introduction of a gas sample, the pressure is approximately 10^{-4} mm mercury. The tungsten filament is heated by a constant voltage source such that a certain fraction of the electrons emitted go through slit S_1 along the path of the arrows to the electron collector box. The electron current is of the order of 5-15 microamperes, and the electron accelerating voltage may be varied from 0-90 volts. Gaseous ions are formed on collision of the electrons with the molecules of the gas sample. These ions are drawn through the slit S_2 by an applied voltage of 25-45 volts, depending upon the nature of the sample. The ion beam is further accelerated from slit S_2 to slit S_3 by a stabilized voltage varying from 300-1000 volts, depending on the m/e ratio of the ions. The ion beam defined by the slits S_2 and S_3 travels in a straight

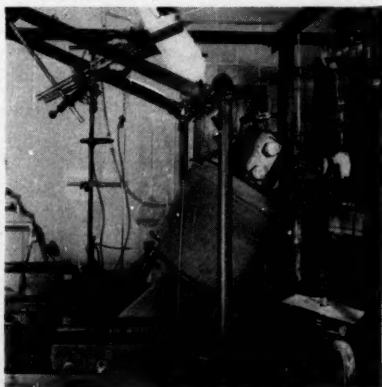


Figure 3. View of the large electromagnet for deflection of the ion beam, the mass spectrometer tube, and the auxiliary magnet around the ion source.

⁴H. L. Johnston and D. A. Hutchison, *J. Chem. Phys.* 10, 469 (1942); D. A. Hutchison, *J. Chem. Phys.* 13, 536 (1945); D. A. Hutchison, *J. Chem. Phys.* 14, 401 (1946).

⁵Research in progress using N^{15} as the tracer in a study of the aminolysis of substituted amidines.

path down the tube, as shown by the arrow-dotted line. The magnetic field is so placed that the ion beam enters the field perpendicular to the lines of force; at this point, it experiences a deflection along a circular path. By suitable adjustment of the ion accelerating voltage and the magnetic field, ions of a particular m/e ratio can be made to follow the arrow-dotted path along the center of the tube, where they experience a 60° deflection, and continue through slits S_4 and S_5 to the ion collector box. The ion current reaching the collector box is of the order of 10^{-15} amperes, and it is amplified by appropriate means and measured with a sensitive galvanometer.

As an example, it might be interesting to consider the analysis for isotopic content of a pure gas such as ordinary nitrogen. With the electric and magnetic fields properly adjusted for the ion $N^{14}N^{15}+$, of mass 29, to pass through the tube to the collector, the ion $N_2^{14}+$, of mass 28, will be deflected more and will hit the upper side of the copper tube, where its charge will be drained off by a connection to ground. The current due to a particular ion is measured by a potentiometric method to avoid nonlinearity of the amplifying circuit. After measuring the current due to mass 29, the ion accelerating voltage is increased until the ion of mass 28 is focused on the ion collector box. Since these two measured currents are respectively proportional to the numbers of two ions of masses 29 and 28, their ratio therefore represents the relative abundance of the heavy and light nitrogen molecules present in the gas sample.

Figure 4 shows a plot of the ion currents in arbitrary units for carbon dioxide against accelerating voltage, obtained from data taken on the Georgia Tech mass spectrometer. The peaks corresponding to masses 44, 45, and 46 are caused by the presence of carbon and oxygen isotopes.

It will be observed that the resolution of these peaks is good; that is, there is little overlapping of the bases of adjacent peaks. Since the peaks are almost completely resolved, no overlapping correction is necessary. It is of interest to compare the curve presented here with that obtained on Nier's original instrument of essentially the same design⁸.

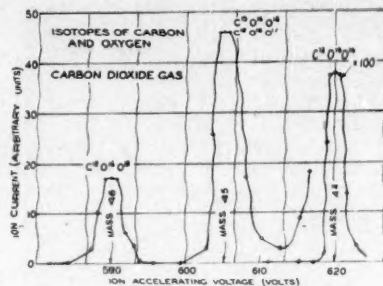


Figure 4. Plot of ion current in arbitrary units for carbon dioxide against ion accelerating voltage. The ion current data are plotted such that the height of the mass 44 peak must be multiplied by a factor of 100.

These data, therefore, show that the instrument serves well the purpose for which it was constructed: the measurement of changes in the relative abundances of isotopes as applied to research problems in isotope separation and tracer studies. These subjects will be considered in more detail in later articles which will appear in THE RESEARCH ENGINEER.

FUNDAMENTAL AND INDUSTRIAL APPLICATIONS

With the advent of the mass spectrometer, one of the first applications was the investigation of the natural distribution of isotopes. This type of study has been important to the geologist in tracing the history of inorganic substances and to the biologist in studying organic processes.

In the study of the separation of isotopes the mass spectrometer has served as an efficient analytical tool to determine the efficiency of the various separation processes. A notable example of this type work is that of Urey and co-workers⁹ on the separation of stable isotopes by the chemical exchange method.

⁸A. R. W. Aten, Jr., and A. S. Keston, *J. Chem. Phys.* 4, 622 (1936); H. C. Urey, J. R. Huffman, H. G. Thode, and M. Fox, *J. Chem. Phys.* 5, 856 (1937); H. C. Urey, M. Fox, J. R. Huffman, and H. G. Thode, *J. Am. Chem. Soc.* 59, 1407 (1937); H. G. Thode, J. E. Gorman, and H. C. Urey, *J. Chem. Phys.* 6, 296 (1938); T. I. Taylor and H. C. Urey, *J. Chem. Phys.* 6, 429 (1938); H. G. Thode and H. C. Urey, *J. Chem. Phys.* 7, 34 (1939); C. A. Hutchison, D. W. Stewart, and H. C. Urey, *J. Chem. Phys.* 8, 532 (1940).

When abnormal concentrations of isotopes became available, it became possible to incorporate the isotopes in chemical compounds and thus label molecules. A new type of experimental procedure became possible in the study of chemical reaction rates. With such labeled atoms, it has been possible to gain much information about physiological processes; for instance, the assimilation of food by animals, a notable example being the work of R. Schoenheimer, D. Rittenberg, and co-workers.⁷

The mass spectrometer, in conjunction with the use of isotopes as tracers, has made possible chemical quantitative procedures not otherwise available. For example, the isotope dilution method developed by D. Rittenberg⁷ makes possible the analysis of complex mixtures such as are frequently encountered in the study of natural products.

The few applications mentioned so far are concerned with problems of fundamental research. Within the last few years, however, the mass spectrometer has expanded its domain of fundamental research to include a number of industrial engineering applications.

In particular, there has been much recent development in the analysis of hydrocarbons. The petroleum industry now employs the mass spectrometer for routine analysis of petroleum products for both research and

control problems. Applications have also been made in the various fields of the chemical industries; for example, those of synthetic rubber and aviation gasoline.

In the field of medical diagnostic work, the mass spectrometer is becoming an important tool in conjunction with use of stable isotopes. Much more will certainly be heard on this subject.

Because the mass spectrometer has thus been developed into a practical instrument for both fundamental and industrial research, it is hoped that the Georgia Tech mass spectrometer will serve directly in the effort to expand knowledge in many fields of interest to Georgia Tech research workers and Georgia industry. The construction of this instrument at Georgia Tech is another step in the program to provide this region with the scientific tools needed for modern research.

ACKNOWLEDGMENTS

The construction of the Georgia Tech mass spectrometer has been a cooperative project of the State Engineering Experiment Station and the Chemistry Department. The writer therefore wishes to express his appreciation to Dr. G. A. Rosselot and Professor J. L. Daniel, the respective heads of these departments. Among other persons who have helped in various ways, the writer wishes to thank Dr. A. O. C. Nier, Dr. D. Rittenberg, Dr. C. A. Hutchison, Dr. D. Stewart, Dr. F. E. Lowance, Dr. W. M. Spicer, Mr. N. R. Henry and Mr. R. S. Leonard.

⁷R. Schoenheimer, S. Ratner, and D. Rittenberg, *J. Biol. Chem.* 130, 703 (1939); D. Rittenberg and G. L. Foster, *ibid.* 133, 739 (1940); S. Groff, D. Rittenberg, and G. L. Foster, *ibid.* 133, 745 (1940).

THE STATE ENGINEERING EXPERIMENT STATION 1945-1946

By GERALD A. ROSSELOT, *Director*
and PAUL WEBER, *Assistant Director*

During the year 1945-1946, the State Engineering Experiment Station had the busiest and most successful year since its formation. Practically every phase of its activity was expanded, and a number of new functions were added to those already existing. Numerous contributions were made in research related to the national security, in industrial research, in fundamental studies,

and in many phases of work directed toward the study and development of the State's natural resources.

Much of this was made possible through use of the largest budget heretofore administered by the Station — approximately \$240,000, of which 67 per cent came from cooperating agencies, industry, and the federal government; 29 per cent from the

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Board of Regents; and four per cent from endowments and grants-in-aid. It is encouraging to note, however, that work already in progress on new projects undertaken for outside sponsors definitely indicates that the budget for 1946-1947 will be considerably larger—the budget for new projects alone approximates \$200,000 so far.

Thirty major research projects and fourteen special projects were prosecuted during 1945-1946, requiring the full time services of 31 persons and the part time assistance of 60 others. During the current year, it is anticipated that more graduate and student assistants will be utilized for work on Station projects and that the permanent staff of the Station will continue to be increased to meet the growing demands for research. Continued cooperation from the regular faculty of the Georgia School of Technology, which itself is undergoing rapid growth, will enable the Station to make maximum use of its facilities.

FACILITIES

During the past year, considerable quantities of new, special equipment were obtained, some through surplus property distributions and some as special gifts. Among these are the Station's electron microscope, considerable photographic equipment, a new crane, various machine tools, new laboratory equipment and supplies, much large-scale refrigeration equipment, and a special gift of German metallographic equipment valued at \$10,000. The value of this new equipment totals well over \$70,000.

Plans were prepared for an addition to the Station building, to be completed within the current year. This addition will almost triple the amount of available floor space and will provide additional small, general research laboratories, in addition to special laboratories for certain fields of work. One of these laboratories will house the new \$100,000 A.C. network analyzer, which will be installed shortly. As the new building is planned, its erection cost is estimated at \$350,000.

PUBLICATIONS

Reports on a number of the Station's research projects were published during the year in the form of technical bulletins and articles. Including those articles written by members of the staff in their fields of spe-

cialization, some 33 publications were released, and 10 others are ready for publication.

However, these publications do not represent all of the Station's progress reports, since many projects are conducted in confidence, at the sponsor's request or under government secrecy orders, hence publication of results cannot be made until a later date.

THE RESEARCH ENGINEER itself represents a new publication activity of the Station, initiated in May. It is under the editorship of the Technical Information Director of the Station.

INDUSTRIAL RESEARCH

The continued effort toward strengthening the industrial research part of the Station's program has resulted in the undertaking of additional outside-sponsored research projects, in addition to the utilization of additional staff members in directing and consulting capacities. New contacts have been made with industries, industry groups and societies, and scientific and engineering societies.

Because of the regularly increasing volume of industrial research and development at Georgia Tech, the Georgia Tech Research Institute was recently organized as a successor to the Industrial Development Council, for the purpose of more adequately handling certain phases related to the Station's outside sponsored work, such as industrial relations and contractual matters.

It is the purpose of the Institute to implement and coordinate the utilization of Georgia Tech research facilities by those industries, associations, government agencies, or individuals who may require these services in the search for new or better products, in the development of technical processes, or in the prosecution of fundamental research. The Institute is a nonprofit organization, separately incorporated under the laws of the State of Georgia and closely integrated with the Georgia School of Technology. Its board of trustees consists of four members selected from the Georgia Tech faculty, four members from the Georgia Tech alumni organizations, and four members from industry at large. The details of this organization were given in an article in the last issue of THE RESEARCH ENGINEER.

EXPERIMENT STATION RESEARCH ENGINEER

Work has continued throughout the year on the Station's Industrial Economic Research Studies. The various state area economic surveys (seven in all) have been completed, and these studies will be summarized in one report covering the entire state if sufficient funds are available. Additional work intended to help improve the State's economy was performed in cooperation with the Agricultural and Industrial Development Council, leading to a number of special Station reports on possible new enterprises within the State.

A director of technical information and a full time staff of assistants have been secured to handle all information searches and other matters (patents, etc.) pertaining to such a division. Coupled with Georgia Tech's excellent library facilities, the Station's Technical Information Division provides a service to industry which is not available elsewhere in the South. Its service functions are described in detail in a separate article in this issue.

RESEARCH PROJECTS

Since the Station and the Georgia Tech Research Institute contract with the sponsors, in many cases, to hold all information confidential until publication is mutually agreeable, it is not possible here to list all of the Station's projects, nor does space permit details of more than a few.

Aeronautical engineering studies were carried out in the wind tunnel, and the broad research program carried on since 1934 on the lifting airscrew and its possibilities as applied to helicopter flight was continued during the year.

Additional work was performed on the study of primers in two coat exterior paint systems on Southern yellow pine, jointly sponsored by the Station and the Southern Paint and Varnish Production Club.

As an outgrowth of a project carried on during the war for the Navy, work was continued on tables and articles on the thermodynamic properties of carbon dioxide, air, oxygen, and argon. An article was published on the properties of carbon dioxide (see RECENT STATION PUBLICATIONS), and the manuscript for the article on air is now in preparation. Experimental studies related to these subjects and to other properties of substances at very low temperatures have been inaugurated to sup-

ply badly needed information for use in gas turbines, jet propulsion applications, etc.

Experimental and pilot plant studies were completed on the impregnation of Southern woods with dimethylolurea, and the sponsor, the Don Gavan Lumber Company, has constructed a full scale plant, based on these investigations.

The Station has designed and tested a new, high-speed peanut planter in a program jointly sponsored by the National Peanut Council. It has engaged in several electron microscope studies, such as a recent investigation on rabies virus in cooperation with the State Board of Health.

Further work was performed on the suitability of Dakota lignite and char as vehicular gas producer fuel, as a result of studies carried out for the Army. Miscellaneous food processing and preparation studies were conducted, and a major program on food preservation, particularly by freezing, has been inaugurated under the joint sponsorship of the Tennessee Valley Authority.

A study on the plant scale chlorination of sewage is being sponsored by the Wallace & Tiernan Company, and confidential projects have been sponsored by the Johns-Manville Corporation; the Monarch Wine Company; L. W. Trueblood & Company; Motor Power, Inc.; the Army Service Forces of the U. S. Army Signal Corps; the Scripto Manufacturing Company; the General Shoe Corporation; and others.

Special projects were conducted for the Atlanta Metal Casket Company, the Fulton Bag & Cotton Mills, the Southern Brick & Tile Manufacturers Association, the Bohn Company, the Rock Wool Products Corporation, and for Colonel J. H. Burke and Mr. N. R. Henry.

The development of a new, light-weight, portable photo-fluoroscopic machine was completed during the year for the S. & H. X-Ray Company, and work was performed to enable this company to manufacture these units on a large scale with knowledge of probable production costs.

Space does not permit details of the fundamental studies conducted on crystal densities, atomic weight determinations, and electrolytic separation; vegetable oil studies; frequency modulation, transmission, and wave propagation studies; and cellulose re-

search. Much of this work has been or will be reported in *THE RESEARCH ENGINEER*.

The State Engineering Experiment Station of the Georgia School of Technology, being the engineering and industrial research agency of the University System of Georgia, serves to coordinate and advance the research activities of the School and to aid directly in the development and integration of the

industrial and agricultural activities of the State through its investigations and technological studies. The past year has witnessed a marked growth in the size and functions of the Station, and it is the earnest belief of Georgia Tech that this expansion will continue at an accelerated pace as more industries and groups become cognizant of the possibilities involved.

SOME PROPERTIES OF MATTER AT LOW TEMPERATURES

I. SUPERCONDUCTIVITY

By WALDEMAR T. ZIEGLER

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INTRODUCTION

There is, at the present time, an increasing technical interest in the properties of matter at temperatures below -40°C . The necessity for designing equipment for use in (a) airplanes operating at high altitudes; (b) the low temperature processing of light hydrocarbons¹; (c) the construction of large air liquefaction plants for producing "oxygen enriched" air for blast furnace operations²; and (d) the building of portable plants for producing pure oxygen gas for military use³ has greatly increased the need for reliable data on such physical properties as tensile strength, brittleness, and thermal and electrical conductivity of metals and alloys, and on the thermodynamic properties of many gases and gas mixtures in the temperature range 0°C . to -190°C . (the boiling point of liquid air).

Until recently, the technical application of temperatures below -200°C . has been nonexistent. Research carried out at Johns Hopkins University prior to and during the war, however, has resulted in the develop-

ment of one possible application, the superconducting bolometer⁴. This instrument, which utilizes a temperature of -259°C . for its normal operation, can be used for detecting the infra-red radiation emitted by objects having temperatures only slightly above those of their surroundings. This device depends for its operation upon the phenomenon of superconductivity (see later).

Another interesting possible application of this low temperature range is the separation of deuterium ("heavy" hydrogen) from hydrogen by fractional distillation at about -253°C . (the boiling point of ordinary liquid hydrogen). This operation might prove a satisfactory source of deuterium for producing heavy water, a material which has shown considerable promise as a moderator in uranium piles⁵.

THE PRODUCTION OF LOW TEMPERATURES

Studies of the properties of matter have necessarily been possible only after means of producing the desired low temperatures have been devised. Historically, the production of temperatures below that of boiling

¹See, for instance, A. W. Pratt and N. L. Foskett, *Trans. Am. Inst. Chem. Engrs.* 42, 149 (1946).

²See, for instance, I. Langmuir, *Chem. Engr. News* 24, 759 (1946).

³See, for instance, paper presented by F. G. Keyes before the Low Temperature Symposium, Atlantic City Meeting, American Chemical Society, April 9, 1946.

⁴D. H. Andrews, W. F. Brucksch, W. T. Ziegler, and E. R. Blanchard, *Rev. Sci. Instruments* 13, 281 (1942); *The Baltimore Sun*, March 9, 1946.

⁵H. D. Smyth, *Atomic Energy for Military Purposes* (Princeton, N. J.: Princeton University Press, 1945), pp. 40, 140, 147.

liquid air followed rather soon after the first reported liquefaction of oxygen by Cailliet and Pictet in 1877⁶.

In 1898, Dewar succeeded in liquefying hydrogen, and the use of this substance extended the possible working temperature range from -220°C. , the lowest temperature easily attainable with liquid oxygen-nitrogen mixtures, to about -259°C. , the triple point of hydrogen.

About 1884, Kammerlingh-Onnes began to establish at the University of Leiden (in Holland) a low temperature laboratory which was destined to become world famous. Methodically, Onnes set about building equipment, first, to produce large quantities of liquid air, next, large quantities of liquid hydrogen (1906), and finally, in 1908, liquid helium (normal boiling point: -269°C.). Temperatures as low as -272°C. can be reached quite readily by causing the liquid helium to boil at reduced pressure.

In order to obtain temperatures below about 1°Kelvin (or Absolute; $0^{\circ}\text{C.} = 273.16^{\circ}\text{K.}$), a new technique was necessary, for, with helium, the last usable gas had been liquefied. It remained for Debye and Giauque⁷, independently, to suggest, and for Giauque and MacDougall⁸ to demonstrate experimentally how temperatures below 1°K. could be obtained by the adiabatic demagnetization of a paramagnetic salt. By this process, a temperature as low as 0.004°K. has been obtained⁹. This is about the lowest temperature which can be reached at the present time.

The production of still lower temperatures by the utilization of the magnetic moments associated with atomic nuclei has been proposed. As yet, however, no experiments of this sort have been conducted.

⁶For a more complete historical discussion and for references on the production of low temperatures, see M. Ruhemann and B. Ruhemann, *Low Temperature Physics* (London: Cambridge University Press, 1937).

⁷P. Debye, *Ann. d. Physik* 81, 1154 (1926); W. F. Giauque, *J. Am. Chem. Soc.* 49, 1864 (1927).

⁸W. F. Giauque and D. P. MacDougall, *Phys. Rev.* 43, 768 (1933); *ibid.* 44, 235 (1933).

⁹W. J. de Haas and E. C. Wiersma, *Physica* 2, 335 (1935).

¹⁰H. K. Onnes, *Leiden Communications*, 122b, 124c (1911). The following books give good summaries of the experimental and theoretical data relating to superconductivity: E. F. Burton, H. Grayson-Smith, and J. O. Wilhelm, *Phenomena at the Temperature of Liquid Helium* (New York: Reinhold Publishing Corp., 1940); D. Shoenberg, *Superconductivity* (London: Cambridge University Press, 1938).

SUPERCONDUCTIVITY

The phenomenon of superconductivity was discovered by Kammerlingh-Onnes¹⁰ at Leiden in 1911 while he was studying the variation of the electrical resistivity of mercury in the temperature range below 5°K. (-268°C.). Onnes observed that as he lowered the temperature of the liquid helium bath, in which the mercury thread was immersed, the resistance of the mercury decreased slowly until a temperature of about 4.3°K. was reached. Below this temperature, the resistance of the mercury decreased very rapidly with decreasing temperature, so that at 3°K. the resistance of the mercury became less than $1/10,000$ of its value at 4.3°K. Figure 1 is a plot of some of the results obtained by Onnes for mercury.

This surprising effect, in which the electrical resistance of a substance decreases from a finite value to a nearly zero value (in the ideal case, very probably zero), usually within a narrow temperature interval, was subsequently found to be exhibited by a large number of pure metals, alloys, and compounds. Such a substance is said to pass from a normal state to a *superconducting* state, in which the electrical resistance of the substance is zero.

It has become customary to speak of the "transition temperature" and the "transition interval" or "transition range" of a substance exhibiting the phenomenon of superconductivity. Taking the resistance of the substance in the normal state at a temperature just above the onset of the rapid decrease in resistance (the point A in Figure 1) as R_n , the "transition temperature"¹¹ is then defined as the temperature at which the resistance of the sample is equal to $\frac{1}{2}R_n$. There is always a temperature interval in which the resistance of the sample remains finite. This range of temperature, corresponding to the points A and B in Figure 1, is called the "transition interval" or "transition range."

¹¹Some investigators apply the term "transition temperature" to the temperature at which the rapid decrease in electrical resistance begins. For pure metals the difference between this transition temperature and that defined above is usually insignificant. However, for compounds and alloys, where the transition interval may be one degree or greater, the difference is obviously considerable.

superconducting transition temperature in the absence of an external field. For the superconducting metals in the right hand side of Table I (the "soft" metals), the variation of the critical field, H_c , with temperature, dH_c/dT , ranges at T_0 from 100 to 200 gauss per degree; for the "hard" metals, such as tantalum and columbium, dH_c/dT varies from about 350 to 1000 gauss per degree. Figure 2 shows these relations for mercury and tantalum.

The existence of the critical magnetic field effect places a limitation on the magnitude of the current which a superconductor can carry. In brief, when the intensity of the magnetic field produced at the surface of the superconductor by the electric current flowing in the conductor exceeds the critical magnetic field for that temperature, the superconducting state is then destroyed, and the substance becomes a normal conductor having a finite resistance. Thus, there is also a critical current effect.

One of the obvious possible uses of a superconductor would seem to be the construction of a solenoid for the production of intense magnetic fields, thus taking advantage of the absence of Joule heat in the superconductor. Unfortunately, the critical magnetic field effect imposes a considerable limitation upon this application.

It was early concluded that if the electrical resistance of a metal in the superconducting state is really zero, it should then be

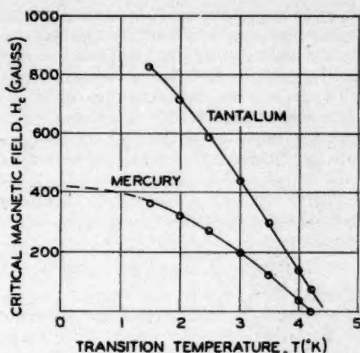


Figure 2. Magnetic field required to destroy superconductivity in mercury and tantalum as a function of temperature (Daunt and Mendelsohn, Proc. Roy. Soc. (London) A160, 129 (1937)).

possible to induce, in a closed superconducting circuit, a "persistent" current which would continue to flow without diminution in strength as long as the circuit was kept at a sufficiently low temperature. This conclusion has been confirmed by numerous experiments¹⁴. The constancy of such persistent currents over many hours has served as one of the most certain means of establishing the fact that a superconductor is actually characterized by a zero electrical resistance.

This is the first in a series of articles dealing with some of the properties of matter at low temperatures.

¹⁴H. K. Onnes and W. Tuyn, *Leiden Communications Supplement*, 50a (1924); K. Steiner and P. Grassmann, *P'ysik. Z.*, 36, 525 (1935).

INDUSTRIAL DUSTS

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"Sanitary engineering" and "industrial hygiene" are terms which today are of increased significance in the South where industry is expanding rapidly. In the Southeastern states alone, according to the U. S. Department of Labor,¹ some 218,000 workers are employed in industries that

present occupational disease hazards, and it is important to note that a good percentage of these involve exposure to industrial dusts.

In some instances, an uncontrolled industrial dust may be merely a nuisance, but in others it may be a health hazard to the

employee group or may involve aggregate annual costs amounting to a staggering figure, especially where the particulate matter contains precious metals or processing stock.

To promote a better understanding of the problems involved in connection with industrial dusts, therefore, this article presents a discussion of the properties of dusts, the physiological responses occasioned by them, techniques utilized in sampling for evaluation of hazards, and methods for their control.

GENERAL PROPERTIES

Dusts, unlike smoke and fumes, are generally formed by the mechanical reduction and dispersion of earthy materials, processes usually associated with such operations as crushing, grinding, buffing, etc. Fumes, on the other hand, are formed by condensation and sublimation and usually involve metals or oxides of metals such as zinc and lead; their particle size is usually below one micron. Smoke is produced by the burning of organic matter and usually has a particle size of less than 0.5 micron.

As may be noted, the particle size or effective diameter of dust particles is usually measured in microns, one micron being 1/25,000 of an inch. Dust concentration may be expressed either in terms of millions of particles per cubic foot or as milligrams per cubic meter.

The chemical and physiological activity of a solid is often considerably increased by reduction in particle size, as a result of the increased surface area formed. For example, the rate of oxidation is increased, resulting in occasional dust explosions if precautions are not taken. It is interesting to note that a cubic centimeter of solid silica, crushed to a particle size of one micron, yields 10^{12} particles whose total surface area is six square meters. If these dust particles were dispersed into the atmosphere in a concentration of 100,000,000 particles per cubic foot, the space occupied by the dispersed system would be 10,000 cubic feet.

It is generally accepted that hazards connected with exposures to such dusts as silica become more significant as the particle size decreases, since only dust particles of the size of five microns or less can reach the alveoli, the parts of the lungs where respiratory exchange occurs between the inhaled atmosphere and the blood stream.

PHYSIOLOGICAL RESPONSES TO DUST

Drinker² has summarized the physiological reactions resulting from the inhalation of dust by classifying the responses into four groups:

Pneumoconiosis. Free silica and asbestos dust are the principal materials producing this response. These cause severe and fatal lung pathology, and are harmful only by the inhalation route of entry into the human body.

Toxic Reactions. These poisonings are produced by such substances as cadmium, lead, or radium, materials which produce harmful effects when taken into the body by inhalation, ingestion, or skin absorption.

Metal Fume Fevers. Fevers of this type are produced by the inhalation of fumes. For example, so-called "galvo" or "shakes" may be produced by the inhalation of zinc oxide fumes.

Allergies. Reactions of this nature are usually caused by a specific protein poisoning.

Physiological responses of peritoneal tissue to industrial dusts have also been classified as absorptive, proliferate, and inert³. Such dusts as calcite are absorbed when deposited in the lungs, while others, such as iron, remain inert. Free silica is proliferate and, consequently, a very harmful dust.

A partial list of some common industrial dusts which fall into these classes would include: (1) absorptive—calcite, gypsum, limestone, pyrolusite, magnasite, and dolomite; (2) proliferate—bisque ware, chert, diatomite, greenware, porcelain enamel frit, quartz, and tripoli; and (3) inert—alumina, alundum, asbestos, coal, bentonite, chromite, fuller's earth, fiber glass, hematite, mica, rock wool, shale, and talc.

COMMON INDUSTRIAL DUSTS

Carbonates. The natural carbonates are usually those of calcium or magnesium, such as calcite, magnasite, and dolomite. Limestone and marble also contain considerable percentages of carbonates, as do cement materials.

Carbonate dusts are not harmful, since they are absorbed by body fluids when they enter the lungs through inhalation. Considerable exposures have been experienced

without discomfort in cement mills, limestone quarries, and similar places.

Sulfates. As may be noted, such sulfates as gypsum fall into the list of absorptive materials.

Metallic Dusts. Metallic dusts and those of their oxides vary considerably in physiological effect. Where the metal is poisonous, as in the case of arsenic or lead, a specific toxic reaction can be expected from the inhalation, ingestion, or skin absorption routes of entry. However, dusts of iron and certain other metals and their oxides appear to be relatively harmless.

Organic Dusts. Organic dusts include those produced from textiles, flour, sugar, wood, and coal. Dust from the latter may irritate the upper respiratory system, while the others may cause conjunctival and cutaneous irritations. Coal mining yields a dust which is composed chiefly of free carbon, but it is usually injurious to the lungs only when it contains a high percentage of free silica⁵.

Silicates. Silicates make up an important class of industrial materials which are used in the production of ceramics and similar types of products. Talc, kaolin, mica, and clays are all silicates, and their wide industrial applications result in the exposure of a great number of employees to this type of dust. For example, in Georgia alone there are 26 brick and tile establishments⁷.

However, asbestos is the only silicate known at the present time which produces a lung pathology comparable to that resulting from exposure to silica dust. As noted in the section on physiological responses, asbestos is classified as "inert," but lung damage is occasioned by an actual sewing up of the aveoli sacs, resulting in dyspnea. Asbestosis differs from silicosis in that fibrosis continues in silicosis after exposure ceases.

Asbestosis and silicosis both take considerable time to develop, the clinical symptoms often taking several years to appear after the last exposure. Asbestosis is frequently encountered in the manufacture of brake linings and fireproof textiles.

Free Silica. The most pathologically important of all industrial dusts is free (uncombined) silica, SiO_2 , which occurs in nature in the form of quartz, flint, sandstone, and chert, and is also associated with many other minerals and ores. Silicosis, the dis-

abling condition which results from the inhalation of free silica, has long been a problem in the stone cutting, granite, foundry, and abrasive industries, in addition to those in which silica is used in processing.

Few industrial operations cause direct exposure to pure silica dust, but there are many fields in which the dusts produced contain at least small percentages of this substance. Regardless of the inherent properties of the other constituents, these dusts are pathologically important because of their free silica content.

A partial list of those workers who are engaged in occupations rendered hazardous by free silica would include abrasive workers, bisque-kiln workers, blasters, brick makers, foundry workers, glass furnace workers, quarrymen, sand blasters, sanding machine operators, scouring powder makers, sodium silicate makers, and tile workers⁹. In Georgia alone, for example, there are approximately 34 establishments which employ 450 people in the manufacture of granite monuments and 10 quarries in which 840 persons are employed⁷.

EVALUATION OF DUST HAZARDS

Several factors must be taken into account in evaluating exposure to a dust: (1) duration, (2) particle size, (3) concentration, and (4) percentage of free silica.

Knowledge of the duration of the exposure is indicative of the total amount of dust which may be expected to have entered the body. Pre-employment examinations are highly desirable in those industries in which exposure may occur, since a worker may have contracted incipient silicosis in a previous position; any past history of exposure is always important. The volume of air breathed, influenced by the physical effort required for the job, also enters the picture, since it directly influences the amount of dust taken into the body.

The rate of development of clinical symptoms of silicosis is dependent upon particle size, although the total damage done to lung tissue is also dependent on the concentration of free silica inhaled. The smaller dust particles are the most important since, as mentioned, dust above five microns in size is screened by the cilia of the upper respiratory system.

Fairly definite maximum allowable concentrations have been established for such dusts as free silica and asbestos, since the concentration of the dust breathed will, within certain limits, determine the possibility of the development of dust diseases.

For both silica and asbestos, 5,000,000 particles per cubic foot is usually considered the maximum allowable working concentration; this limit also holds for mixed dusts when the percentage of silica times the total number of particles exceeds this value⁶. There are certain maximum allowable limits for any dust, of course, even if only nuisance value is involved; a limit of 50,000,000 particles per cubic foot is usually set.

Finally, the nature of the dust is of the greatest importance, particularly for the mixed dusts containing free silica which produce the majority of industrial exposures. For example, the free silica content of certain selected industrial dusts is as follows⁹: bisque ware, 72 per cent; chert, 76; diatomite, 92; greenware, 69; porcelain frit, 35; quartz, 99; and tripoli, 98 per cent.

DUST MEASUREMENTS

In the evaluation of factors which influence dust hazards, direct measurements are necessary to obtain accurate information on exposures. Such measurements are made by the actual collection of dust samples, the counting of dust particles, and petrographic identification or chemical analysis.

Early work on silicosis control was performed with the use of the Zeiss Konimeter, but other instruments have enjoyed greater popularity in this country. The electrostatic precipitator or the filter-paper dust collector are probably the best instruments from the standpoint of collecting efficiency, but most of the correlations of dust concentrations with medical findings have been based on samples collected and counted by the Greenburg-Smith technique⁶ in which an impinger unit is employed, microscopic counting being performed under the light field microscope.

The percentage of free silica in a dust sample is usually determined by either chemical or petrographic methods.

CONTROL

Most of the companies which have successfully dealt with dust control, of which

several outstanding examples can be found in Georgia, usually consider such operations as part of the over-all production pattern and, consequently, have employed sound engineering procedures in integrating control methods with general plant operations.

Of the several methods for the control of dust, which include wetting down, enclosing the system, and using personal protective devices, ventilation—either general or local exhaust—probably offers the most satisfactory solution.

Respirators should be used only where other methods for control of the atmosphere cannot be economically applied. When their use is mandatory, however, certain factors should be considered:⁸ (1) their breathing resistance should be two inches of water or less, (2) they should be comfortable, (3) they must fit snugly and properly, providing adequate vision, and (4) they must give efficient dust removal.

General ventilation can occasionally be used to good advantage for the control of dust in industrial operations. This method is used in the Le Tourneau Company Foundry at Toccoa, Georgia, for vertical removal of smoke and dust from arc furnaces, the fan serving this installation removing 60,000 cubic feet of air per minute.

Of particular importance in any installation where general ventilation is to be applied is the fact that this method, being a remedy based on dilution, does not always give protection to persons in the immediate area where the contaminant is being dispersed into the atmosphere. For this reason, general ventilation should be employed only where careful analysis indicates its adequacy.

Local exhaust ventilation is the application of exhaust at the point of liberation of a contaminant. By use of this procedure, the dust is removed from the atmosphere before it has an opportunity to escape directly into the work area. This method is widely used and has been found extremely effective, for example, in the control of dust from granite cutting operations. In such installations, a flexible duct is employed, usually fitted with a small entrance hood to increase the capturing velocity; this hood may be placed in any desired position adjacent to the operation, usually about 6-8 inches away.

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For work in granite and stone cutting sheds, 500 cubic feet per minute are usually removed through each flexible duct for hand tool operations and approximately the same volume for surfacing machines. The capturing velocity necessary for the control of dust in certain industrial operations is indicated by the following figures (linear velocity in feet per minute):⁴ (1) granite cutting—pneumatic, 200; surfacing, 1,500; (2) grain elevator—elevator boot, head, and garner, 500 (at hood face); and (3) in sand pulverizing, at the bagging machine, 400.

* * *

From the foregoing discussion, it is evident that industrial dusts present problems which have direct bearing upon the physical welfare of the worker. Any progress which can be made in the study of the effects of dusts, in the elimination of hazards, and in the development of better methods of control are therefore of definite advantage to both management and personnel.

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Figure 1. Proper use of local exhaust ventilation on foundry shakeout. (Courtesy of American Air Filter Co.)

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RECENT STATION PUBLICATIONS

BULLETINS

Taylor, J. L., *The Processing of Domestic Flax for Textile Use. I. Decortication*, Georgia School of Technology, State Engineering Experiment Station Bulletin No. 9, 1946, 28 pages, 75 cents.

Since it seemed possible that flax might become a new crop for the Southeastern region, that flax processing might create a new industry to add to the region's development, that the fibers produced might provide new and interesting opportunities to the textile industry of the South, and that by-products such as flaxseed might have im-

portant economic potentialities, the Tennessee Valley Authority established in Georgia a coordinated program in this field whereby the research on the processing and utilization of the flax and straw was conducted at and jointly sponsored by the State Engineering Experiment Station.

This first of four bulletins on this project describes the experimental work on decortication (removal of bark and woody core), including investigations on crimping rolls and auxiliaries, differentially-speeded rolls, oscillating rolls, flexing rolls, and a disinte-

grator. The decorticator finally developed contained eleven pairs of rolls of decreasing coarseness and five pairs of rolls with circumferential grooves, arranged in various orders.

The production of clean (shive-free), decorticated flax fibers is not a simple matter, nor can optimum results be obtained by the use of a single mechanism. The experiments reported in this bulletin, however, have indicated that the best system of machines consists of (1) a stapling machine, (2) retting tanks (including loading and unloading equipment), (3) a tunnel dryer, (4) a decorticator, (5) a dusting machine, and (6) a fiber condenser. B. H. W.

Taylor, J. L., *The Processing of Domestic Flax for Textile Use. II. Retting and Degumming*. Georgia School of Technology, State Engineering Experiment Station Bulletin No. 10, 1946. 24 pages. 75 cents.

As mentioned in the first bulletin of this series, decorticating alone does not yield as usable and desirable a fiber as that produced by retting, decorticating, and degumming. The second bulletin describes experiments on degumming with alkaline solutions, carbonate-sulfide mixtures proving very suitable for either retted or unretted fibers. Bacterial (water) retting proved superior to attempts to duplicate it chemically: "flax straw even of the poorest quality, if retted, will generally yield a fiber usable in blends." Experiments on washing, drying, and opening are also discussed in detail. B. H. W.

REPRINTS

Burrows, W. H., *The Nomographic Representation of Polynomials*. Georgia School of Technology, State Engineering Experiment Station Reprint No. 13, 1946. 15 pages. 25 cents.

Standard methods for the nomographic representation of polynomials in three and four variables are usually given for very limited ranges of the variables. The use of ranges frequently encountered in engineering practice makes these methods inaccurate and difficult to employ.

This reprint of an article from *The Journal of Engineering Education* describes a chart which has been devised for adjusting the moduli of the scales to fit the ranges of the variables, at the same time fixing the position of points on the base scale of the nomograph. Its use is described in Part I, while the method as a whole is reduced to

simple steps applicable to all polynomials of not over four variables.

In Part II, two methods for the treatment of polynomials of five variables are given. Previous methods require the reduction of the polynomial to one of four variables, which is indirect, or construction of a complicated network of curves. The methods given here are direct and follow the simple methods outlined in Part I.

Sweigert, R. L., Weber, Paul, and Allen, R. L., *Thermodynamic Properties of Gases. Carbon Dioxide*. Georgia School of Technology, State Engineering Experiment Station Reprint No. 16, 1946. 16 pages. 25 cents.

In this reprint of an article published in *Industrial and Engineering Chemistry* is described the preparation of a large (30 x 80 inch) thermodynamic chart of the properties of carbon dioxide, prepared for the Design Research Section of the Bureau of Ships, U. S. Navy.

Specific volume, enthalpy, and entropy values for carbon dioxide are plotted on the chart at temperatures -75° to 1800° F., over a range of specific volumes 0.1 to 1000 cubic feet per pound for pressures up to 3000 pounds per square inch. All available experimental data were gathered and used as a basis for the chart; and these data, as well as their use, are discussed in the article. The calculation and approximation methods employed to obtain values over ranges for which no experimental data exist are also described, and values for specific volume, enthalpy, and entropy are tabulated.

Burrows, W. H., *Construction of Nomographs with Hyperbolic Coordinates*. Georgia School of Technology, State Engineering Experiment Station Reprint No. 17, 1946. 6 pages. 25 cents.

This reprint of an article which appeared in *Industrial and Engineering Chemistry* deals with the problem of adjusting the moduli and positions of the scales of a nomograph in order to increase legibility. It is treated from the standpoint of the coordinate system rather than the defining equation of the nomograph.

A coordinate system is described such that variations in the value of a single factor, r , will produce the desired variations in the positions and moduli of the scales. The general defining equation for nomographs is derived and shown to be inde-

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pendent of r , thus the scale arrangements can be altered without changing the original equation of the nomograph. The mechanics of constructing nomographs on this coordinate system and the method of selecting the desired value of r are illustrated by the construction of three nomographs.

CIRCULARS

Weil, B. H., Rosselot, G. A., and Koza, R. W., *The Electron Microscope at Georgia Tech*. Georgia School of Technology, State Engineering Experiment Station Circular No. 4, 1946. 5 pages. Gratis.

A description of the development, theory, and applications of the electron microscope. This instrument makes possible magnifications as high as 100,000 diameters, compared with 2,000-3,000 for optical microscopes, and also possesses far greater resolving power. Instead of focusing light rays with glass lenses, the electron microscope employs a series of magnetic fields to focus a stream of electrons, the image being cast upon a fluorescent screen or photographed directly. Diffraction patterns can also be easily photographed.

Applications of the instrument include particle size measurement, such as for carbon black, clays, and rosin sizes; studies of paper, textiles, and photographic emulsions; and numerous uses in biology, metallurgy, and chemistry. The instrument at Georgia Tech has already found use in several of these fields and constitutes an important tool for research in the Southeast. B. H. W.

SPECIAL REPORTS

Economic Study of Rome Area. Industrial Economic Research Staff, State Engineering Experiment Station. Special Report No. 20, 1946. 271 pages. Four dollars.

This is the sixth in a series of similar studies of Georgia areas and deals with six counties, five in northwest Georgia and one in Alabama; the Georgia counties include Bartow, Chattooga, Floyd, Gordon, and Polk. A survey is made of the factors which affect the industrial growth of the area—housing, population, income, weather, labor force, taxes, and agriculture—and a detailed analysis is made of those industries which exist in the region or which seem logical of development there for various reasons.

Such industries include iron and steel, lime, cement, brick and tile, glass and sand,

whiteware, plastics, timber, paper, clothing, and food preservation. The study, prepared for the Rome Chamber of Commerce and the Agricultural and Industrial Development Board of Georgia, is concluded with a county-by-county statistical analysis. B. H. W.

Economic Study of Northeast Georgia. Industrial Economic Research Staff, State Engineering Experiment Station. Special Report No. 21, 1946. 282 pages. Four dollars.

This study deals with the northeast Georgia area in a manner similar to that described above for the Rome area. The sixteen Georgia counties included in this study are Banks, Barrow, Dawson, Forsyth, Franklin, Habersham, Hall, Hart, Jackson Lumpkin, Madison, Rabun, Stephens, Towns, Union, and White.

Industries analyzed include granite, gold, refractories, brick and tile, glass and sand, timber, paper, handicraft, plastics, clothing, and food preservation. Tourist and recreational possibilities are also discussed. A statistical analysis of each county concludes the study, which was prepared for the Northeast Georgia Development and Planning Association and the Agricultural and Industrial Development Board of Georgia. B. H. W.

Hosmer, Joseph B., *The Need for More Peanut Processing Plants in Georgia*. State Engineering Experiment Station. Special Report No. 22, 1946. 21 pages. Gratis.

This report deals with the economics of peanut processing in Georgia, with emphasis on market characteristics, uses, new products, and agricultural trends. If Georgia is to maintain her present leadership in peanut production and processing, much attention must be given to all these subjects.

B. H. W.

Weil, B. H. and Sterne, Frances, *Literature Search on the Preservation of Foods by Freezing*. State Engineering Experiment Station. Special Report No. 23, 1946. 420 pages. Four dollars.

Frozen foods are now in widespread use, but much research is still needed to improve their quality and to develop better and more economical methods of production. The State Engineering Experiment Station, as part of its long-term engineering research program in this field—which program is jointly sponsored by the Tennessee Valley Authority—has prepared this indexed, expanded bibliography of the pertinent literature, so that future research might benefit

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through use of and acquaintance with the existing data.

The search contains 1722 literature abstracts, arranged alphabetically by author, and 373 patent digests, arranged in numerical order. A detailed alphabetical subject in-

dex makes possible access to references on many divisions of the field. This search has been prepared by the Station's Technical Information Division as part of its program to organize and make more readily available the information contained in the technical literature. B. H. W.

REPORT FROM THE LIBRARY

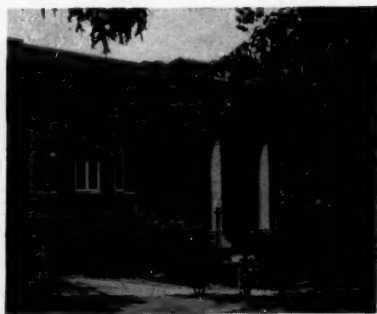
By DOROTHY M. CROSLAND
Librarian, Georgia School of Technology

As mentioned in the first installment of this series, the Georgia Tech library is a tool which is available for use in your search for knowledge; as such, it is an essential instrument in industrial applications. Although the library's resources are intended chiefly for the use of our students and faculty, all engineers, research workers, and visitors are welcome to use the materials within the building.

The administrative officers of the School have realized that we can become a great engineering library if we recognize and assume certain responsibilities. New services in a library are costly, however, and both space and help must be provided. At the present time we do not have enough of either, but we are looking to the future. It is our plan to expand our services each year, to make this library an essential tool for better living in an engineering era.

One new service recently undertaken is the collecting of printed copies of United States patents. This is a significant step because, as far as we have been able to ascertain, there is not a single patent collection in the entire South. We are now receiving the patents for 1946 and should like to have copies for at least the past twenty-five years. It will take some time to assemble and find space for these back issues, but our small beginning has already brought many enthusiastic comments and requests.

The chief of the Division of Patent Administration, Alien Property Custodian, Washington, D. C., has recently written that "It is good news that the Georgia School of Technology is assembling a collection of United States patents, for such



a collection is badly needed in the Southeast. You are doubtless aware of the continued efforts which this Division of the Agency has made to stimulate the interest of American industry in the storehouse of technical information contained in the seized patents. It is with the thought of widening the accessibility to this material that I suggest placement on a loan basis of a set of our abstracts of vested mechanical-electrical patents in your library."

I am happy to report that our library now has copies of the abstracts of all the chemical patents and the mechanical-electrical patents which have been vested in the Office of the Alien Property Custodian. These abstracts are available to research scholars, patent attorneys, and to all visitors who wish to use them. I quote from the "General Information" regarding the enemy patents:

A wealth of technical information has been made available to American manufacturers through the United

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States patents formerly owned by our enemies and seized by the Government during the war. Thousands of ideas for new materials, new processes and new products are disclosed in these patents which now are being put into use by American industry under a liberal licensing program administered by the Alien Property Custodian. These patents cover a very wide range of industries. They should be of special interest to small business enterprises, ex-service men seeking opportunities to engage in manufacture, research organizations, engineers and technicians.

This library shall attempt to answer requests for assistance in locating particular inventions of interest; we invite you to come in to use our patent material.

We are also to receive some 35,000 reports from the Office of Scientific Research and Development, through which office we have already received approximately 650 reports from the Radiation Laboratory of the Massachusetts Institute of Technology. Members of the faculty and research students are eager to use these radar reports, which have been restricted up to this time, and we feel that the acquisition of this material is another step forward in our research program.

While it is sometimes impossible to buy or even to borrow a certain journal or book it is usually possible to obtain a microfilm of the material in question. The library has recently acquired a very fine microfilm reader, thus making valuable and rare material available through microfilm service.

Along with the more serious obligations to research, we have assumed one of providing music for the pleasure of our students. In 1941, the Carnegie Corporation of New York, along with the Student Lecture Association and the Student Council, gave the library a record player and some 450 classical records. A small room on the ground floor was made sound proof and the collection installed. It would be impossible to tell you of the pleasure this collection gave the students during the war years; the set is now almost worn out. One of our professors of electrical engineering made the statement that our phonograph was used more in one week than the average home machine in one year. During the war, it was found that music stepped up production. Many aircraft factories provided music 24 hours per day. It

certainly seems logical, then, that music should have a place in our engineering school.

Undoubtedly the most important project of our library is the acquisition of outstanding journals, current and back files, and transactions and proceedings of the more important engineering and scientific societies of the world. At present, we receive approximately 1400 journals, either by subscription or gift, and for many of these we shall attempt to secure complete files. These periodicals are invaluable to our graduate students and research workers.

Our most valuable acquisitions have been made since 1939, for it was in December of that year that we received a donation for the purchase of scientific and technical journals to further graduate study.

The following journals and reference books were added in 1940: *Aeroplane (London) (1911-1938)*; *American Water-work's Association, Journal (1914-1939)*; *American Society for Metals, Transactions (1922-1939)*; *Astrophysical Journal (1895-1926)*; *Bulletin de la Societe Chimique de France (1858-1939)*; *Chemical Age (London) (1919-1939)*; *Chemiker-Zeitung (1880-1938)*; *Chemisch Weekblad (1903-1939)*; *Chemisches Zentralblatt (1831-1933)*; *Chimie et Industrie 1918-1939*; *Compte Rendus Hebdomadaires des Seances de l'Academie des Sciences (1835-1934)*; *Deutsche Mathematiker Vereinigung Jahresbericht (1890-1939)*; *Gmelin's Handbuch der Anorganischen Chemie*; *India Rubber World (1912-1939)*; *Institution of Chemical Engineers, London, Transactions (1923-1939)*; *Institution of Electrical Engineers, London Journal (1872-1938)*; *Institution of Mechanical Engineers, London, Journal (1927-1938)*; *Journal of Physical Chemistry (1915-1928) (completed in 1945) (1896-1914)*; *Kolloid Zeitschrift (1906-1935)*; *Metal Progress (1920-1936)*; *Paper Industry (1919-1937)*; *Paper Trade Journal (1926-1939)*; *Philosophical Transactions of the Royal Society, London (1887-1939) (1849-1886 issues purchased in 1945)*; *Physical Society, London, Proceedings (1874-1939)*; *Rayon (1925-1933)*; *Rubber Age (1917-1939)*; *Society of Chemical Industry, London, Journal (1882-1938)*; *Textile Institute, Journal and Transactions (1925-1933)*; *Zeitschrift*

des Vereines Deutsche Ingenieure (1900-1933; lacks several volumes); *Zeitschrift fur Technische Physik* (1920-1936); *Zentralblatt fur Mathematik und Ihrer Grenzgebiete* (1931-1934) and *Zeitschrift fur Anorganische und Allgemeine Chemie* (1892-1934).

In the next issue of this publication, I shall continue the list of acquisitions beginning with 1941, in order to give you some

idea of the growth and expansion of the library facilities at Georgia Tech.

Correction. The equation for the hood of a local exhaust ventilation device, given on page 22 of the May, 1946, issue of THE RESEARCH ENGINEER, should have been:

$$Q = V(10X^2 + \dot{A})$$

TECHNICAL-INDUSTRIAL PROBLEMS

The State Engineering Experiment Station receives many questions of a technical or economic nature, dealing with various problems which affect this region's economy. Some of the answers to these may prove of general interest and, where confidences are not violated, will appear in this section.

Q.: I understand that starch is being prepared commercially from sweet potatoes. Do you have any information available on this subject and on sweet potato dehydration? H. F. O.

A.: Our work here has so far been restricted to preliminary economic studies on these topics, so we do not have any special reports available.

We understand, however, that the United States Sugar Company is operating a sweet potato starch plant at Clewiston, Florida, and another plant was operated, until recently, at Laurel, Mississippi. Many of the factors involved in this process were recently discussed in *Chemical and Engineering News* 24, No. 11, 1518 (1946).

Considerable work on dehydration and starch production has been performed by the U. S. Department of Agriculture, at New Orleans; the Mississippi Experiment Station; Auburn (Alabama Polytechnical Institute); and the Louisiana Agricultural Experiment Station, at Baton Rouge.

Among papers published in recent years on the industrial uses of sweet potatoes are "Dehydrated Sweet Potatoes for Ethanol Production," J. A. Jump et al. *Industrial and Engineering Chemistry* 36, No. 12, 1138 (1944), and two papers presented at meetings of the National Farm Chemurgic Council: No. 317, "Production of Sweet

Potatoes for Industrial Uses," by Julian C. Miller, and No. 380, "Sweet Potato Possibilities in Texas," by Gilbert C. Wilson. B. H. W.

Q.: I am puzzled by the fact that the Bureau of Census figures for 1939 show a price for nitrous oxide of \$0.009 per gallon. I have heard that the Germans used liquid nitrous oxide for the immersion freezing of fruits and vegetables and wonder if this agent, because of its low price, might not prove highly economic in this country? G. H. M.

A.: Liquid N_2O might prove economic for immersion freezing in this country, but not because of its low price. The Bureau of the Census does not always mention that its average cost figures for this chemical are for gallons of gas at N.T.P. This means that liquid N_2O would have cost about \$4.00 per gallon in 1939. Lower costs might be obtainable, however, since this chemical is usually produced by a small-quantity batch process for anesthetic use.

The Office of Technical Services of the U. S. Department of Commerce has released several reports on the German use of this process, among which are OPB reports 1250, 1269, and 2039. These reports indicate that the process is technically interesting and that it might prove economic, perhaps with the use of a different freezing media. T. V. A., incidentally, has developed an interesting immersion process, and you may be interested in some of the many references to immersion freezing in the Station's recent *Literature Search on the Preservation of Food by Freezing* (see RECENT STATION PUBLICATIONS). B. H. W.

Q.: We are very much interested in using pecan shells in our operations. Can you give us any information on the tonnage of pecans produced annually in Georgia, the percentage of shells by weight, etc? E. S. F.

A.: Georgia production of pecans averages about 20,000,000 pounds per year, with the proportion of hulls about 54.5 per cent for the Stuart variety, 41.0 per cent for the Schley type, and 56.5 per cent for seedlings. The proportion of pecans shelled varies widely from year to year. If all nuts were shelled, the total annual production of hulls would be about 11,000,000 pounds, but it is probable that the average volume

of hulls accumulated by all commercial plants ranges from 3,000,000-4,000,000 pounds per year.

Many of your questions are answered in Station Bulletin No. 4, *Studies in the Utilization of Georgia Pecans*. This bulletin reports that qualitative analysis of hull ashes shows the presence of calcium, potassium, magnesium, and sodium, in the form of carbonates, phosphates, and sulfates. Silica is also present. Charcoal can be produced from pecan hulls by heating for several hours at 300-500° C., and an activated charcoal can be produced by a somewhat more elaborate procedure. Other chemical uses are possible. J. B. H.

INFORMATION SERVICE AT TECH

By B. H. WEIL

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Modern research, industrial and fundamental alike, has become a complex process, based upon the knowledge of the past and the logical and intuitive reasoning of the present. Its performance usually requires more than the simple laboratory bench or machine shop, and the number of untrained inventors—always small—is likely to continue to decrease.

Whether the research unit be large or small, however, one factor in each new problem is always the same: "What has been done on this question before?" A similar situation often arises in industrial operations, especially where there are technical aspects: "Is there a known answer to our particular problem?"

If the research worker or industrial operator is experienced in the field, his first resort is reference to his own small library, for many problems can be solved without great difficulty in this manner. If the problem is complex or abstruse, however, it is unlikely that any one or two books or journals will contain more than a clue, and it becomes necessary to make reference to the full resources of a technical library—or to find the answer by research.

The latter approach is all too commonly accepted these days by those who (1) do not possess access to a good library, (2) do not have the time, training, or inclination to conduct an organized search through the modern "jungle" of books and journals, or (3) do not clearly understand the value of complete background information and the dangers (as well as economic waste) involved in making an "invention" or developing a "new" phase of a process which may already have been patented or described.

These dangers are all too real, as many inventors have discovered to their sorrow when they see days or years of painstaking efforts go to waste because someone had previously patented their exact idea. Similarly, it is equally tragic to spend perhaps thousands of dollars for research on a problem whose answer has already been published and is available for use.

It is obvious, of course, that the scientific and technical literature does not contain the answers to all of the problems which beset both research and industrial operations, but it is equally clear that no important research project should be started without a thorough analysis of the published information and

the organization of the latter in such a manner that it can be used for ready reference as the work progresses.

To meet these needs, many large industrial organizations have created, as part of their library functions or as separate research or service organizations, whole divisions whose duty it is to provide the necessary information in the desired form. Smaller companies and research groups, lacking the necessary funds, are often forced to be satisfied with small libraries and few "library" services, but their need is fully as great as is that of their larger competitors.

TECH'S INFORMATION DIVISION

Recognizing all this, and having access to the best technical library in the South (as can clearly be seen from the REPORT FROM THE LIBRARY), the State Engineering Experiment Station of the Georgia School of Technology has put into operation its Technical Information Division. This Division is used to provide the Station with background information on its various research projects—industrial and fundamental—and to aid in the Station's program of industrial service to Georgia and the South. Its services are made available to industry through the auspices of the Georgia Tech Research Institute, on a nonprofit basis.

The Technical Information Division is staffed to provide several varying services. On request, it can conduct complete literature and patent searches on any technical subject, arranging abstracts of these in a logical manner and indexing their contents for ready use. Such a search is described in Station Special Report No. 23, which abstract appears elsewhere in this issue.

The use of searches of this nature usually requires that the reader have access to a good library, so that further details may be acquired from references pertinent to any phase of the subject, although microfilm or photostat services may also be used.

There are many problems, moreover, that do not possess such broad ramifications and which may be answered—insofar as an information search is concerned—by a summary of the pertinent data located by the searcher. Such summaries are prepared by the Technical Information Division when

the occasion warrants the use of this form of presentation.

In addition to the analysis of past information, the Division is equipped—through the use of the Georgia Tech library—to prepare running summaries of the current literature, either in abstract or digest form as the case may be. Such summaries are of value in keeping the worker abreast of his field and often serve to provide him, without loss of time, with some vitally needed but hitherto unavailable information.

The Station's Industrial Economic Research Staff cooperates closely with the Technical Information Division on economic aspects of problems and is itself equipped to prepare economic studies on problems of importance to this region.

PATENT SERVICE

Realizing also that the industries of this region have available only limited patent services and that no general patent library exists in the South—a defect which the Georgia Tech library is planning to remedy—the Technical Information Division is also prepared to handle patent searches where these deal with matters concerned with or anticipatory to Station research problems. In this manner, the Station is enabled to provide its research services with assurance that neither its nor its sponsors' time and money will be wasted.

* * *

Scientific and industrial research and development have accomplished much in the past few decades, and the results of these endeavors have been reported in millions of books, journal articles, and patents. So voluminous has been this flood of information that library walls throughout the country are literally bulging, while scientists and industrialists alike, confounded by the vastness of this storehouse of information, are often at a loss to make proper use of it.

The Technical Information Division of the State Engineering Experiment Station is prepared to help industries of this region in the solution of their informational problems, large or small. Knowledge obtained by others and reported by them is their contribution to civilization, and its use in an effective manner is both logical and economic.

